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WEAPONS SYSTEMS RESEARCH LABORATORY

DEFENCE RESEARCH CENTRE SALISBURY
SOUTH AUSTRALIA

TECHNICAL REPORT

WSRL-0102-TR

EXPLOSIVE GENERATION OF CHAFF [U]

I.M. NAPIER and I.L. THOMPSON

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14 WSRL-0102-TR

6 EXPLOSIVE GENERATION OF CHAFF [U]

10 I.M. Napier [redacted] I.L. Thompson 8

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S U M M A R Y

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A new concept for the explosive generation and rapid dispersal of chaff for electronic countermeasures has been investigated. Promising results were obtained in static tests but these and theoretical estimates of radar cross section conflicted with the very low values actually obtained in experiments monitored by radar. Very short bloom times were realized in these experiments.

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1. INTRODUCTION

"Chaff" has been in use as an electronic countermeasure since the early 1940's and still maintains a very important position despite significant advances which have since been made with other devices such as microwave transponders.

Various techniques are in use for dispensing chaff. These include ejection of pre-cut material from aircraft, rockets and shells, and aircraft borne high speed cutters fed with rovings of aluminium coated glass filaments or aluminium foil. Dispersal ("blooming") in most cases relies on aerodynamic forces.

Very rapid blooming is an essential feature required for aircraft defence when sophisticated radar sets are involved which can discriminate between the target and its chaff decoy if they are separated by more than a few tens of metres. Such chaff is known as track break chaff and is usually bloomed by a combination of the effects of a small dispersal charge and aerodynamic forces. An alternative technique, which promised very rapid blooming through explosive cutting and subsequent dispersal of chaff by the blast wave, was considered at WSRL. The basis of the technique is an explosive filled multifluted linear shaped charge located within a spool of fine wire which is cut into dipoles on initiation of the charge. In this work the dimensions of the cutter and of the spool were chosen to produce dipoles with an average length of 25 mm. This is the near optimum length for the L-band radar at Woomera which had been chosen for use in effectiveness tests. The technique and its assessment are described in detail in this report.

2. EXPERIMENTAL

2.1 The multifluted linear shaped charge

Shaped charges were fabricated from 1 mm thick copper strips 20 mm long, bent through 90° and soldered together at the edges to produce a six fluted linear shaped charge as shown in figure 1. Individual charges of lengths 20 mm and 40 mm were made in this manner and filled with explosive. The explosive used in most cases was PE4 but in some experiments a polymer bonded explosive containing 88% RDX was used. There was little difference in performance with either explosive. Charges were stacked to the required length and in some instances successive charges were staggered slightly to yield either a 30° or 60° twist over the total length of 150 mm. This was done to investigate the effect of changing the cutting pattern on the extent of birdnesting. Initiation was with a No. 8 detonator in conjunction with a tetryl booster (10 mm long x 10 mm diameter). For the static experiments and the first Woomera trial, an electric detonator was used but in the second Woomera trial a plain detonator was used crimped around a length of Bickford fuze to give a 20 s delay after initiation of the fuze. This is shown in figure 2. Initiation of the fuze was by an F53 match head wired in series with the rocket motor firing circuit. The assessment of cutting ability was carried out using single fluted charges 20 mm long with the same liner dimensions as those above. Assessments were carried out on 25 mm thick tightly packed bundles of steel wire and of glass filaments coated with aluminium, representing the two materials used in this investigation.

2.2 Dipole material

Experiments were carried out with piano wire (0.2 mm diameter), stainless steel wire (0.1 mm diameter, medium hard) and glass filaments coated with aluminium (0.02 mm diameter). For experiments other than those mentioned in Section 2.1 designed solely to assess cutter performance, the dipole material was wound onto a spool of fibre reinforced plastic as shown in

figure 1. The spool was 100 mm long, the ID was 35 mm (with a 2 mm wall) and the overall diameter was 60 mm. The end plates, which were 2 mm thick, were attached to the central tube using epoxy resin. With a six fluted cutting charge and a spool of wire of these dimensions, dipoles ranging in length from 20 mm (core windings) to 30 mm (peripheral windings) were obtained.

2.3 Static firings

Static firings were carried out both in an enclosed detonation chamber and unconfined in a field. In all cases the cutter protruded 40 mm at the initiated end (and 10 mm at the other) to allow for the forward throw of the cutting blade and to establish steady detonation. The weight of explosive was 210 g. The device was set vertically 0.5 m above the floor in the detonation chamber and on a post 1 m high in the field. In the latter experiment a quadrant of the circle surrounding it on the ground was covered with hessian to facilitate the assessment of chaff dispersal. The chaff was collected from marked areas of the hessian with a strong permanent magnet.

2.4 Radar observed experiments

2.4.1 Helicopter suspended chaff generator

The firing was conducted at Woomera to Trials Instruction No. CA24 (ref.1). Several generators were prepared - some with 30^{o} twists in the cutter and some straight. The length of each cutter was the same as in 2.3 above. Each generator was inserted into a cellulose acetate tube (2 mm thick) fitted with wooden end plugs and a large stabilizing plastic fin (as shown in figure 3). The generator was then attached to one end of a 600 m cable which served both for lifting and for passage of a firing current from a portable firing box in the helicopter. Initiation took place with the generator suspended 900 m above the ground.

2.4.2 Rocket launched chaff generator

These experiments were also carried out at Woomera. Sighter rockets (3 in) were used and were fitted with heavy heads (27 kg) into which the generators were bolted (figure 4). They were launched from a mobile launcher with an elevation of 75^{o}. Full details are given in Trials instruction No. CA30(ref.2). The generators used were essentially the same as in 2.4.1 but of the six cutters used only wo were twisted and the twist angle was limited to 30^{o}. One spool contained piano wire (0.2 mm diameter) while the remainder contained stainless steel wire (0.1 mm diameter). Two spools (stainless steel wire) were only partially filled in order to assess the effect of reducing the thickness of steel to be cut (from 12 mm to 9 mm). Details of the generators used are shown in Table 1.

TABLE 1. DETAILS OF ROCKET LAUNCHED CHAFF GENERATORS

Identification number	Wire type	Wire quantity		Number of dipoles* (approximate)	Cutter design
		Mass (g)	Length (m)		
1	Stainless steel	570	8,413	336,500	straight
2	Piano wire	900	3,600	144,000	straight
3	Stainless steel	880	13,000	520,000	straight
4	Stainless steel	880	13,000	520,000	straight
5	Stainless steel	880	13,000	520,000	twisted (30^o)
6	Stainless steel	570	8,413	336,500	twisted (30^o)

(* based on an average length of 25 mm)

Each generator was fitted with a 20 s delay as described in 2.1. It was predicted, from data in reference 3, that initiation would occur at an altitude of about 4 km.

2.4.3 Radar

The radars used for the rocket borne experiments were the Adour(R1) and the AN/FPS-16(R38). These sets were approximately 2.6 km and 34 km (slant range) respectively from the point of burst. R1 was used alone in the experiment involving the helicopter borne chaff generator. In this experiment the slant range was 3.5 km.

3. RESULTS AND DISCUSSION

3.1 Cutting tests

Single linear shaped charges (L.S.C.'s) were fired against 25 mm thick bundles of piano wire and aluminized glass filaments (both tightly packed). The stand-off was 4 mm (approximating to the stand-off to be used in the later experiments). Cutting through the full 25 mm thickness was achieved in each case. Although the steel wire was cut cleanly the cut ends of the glass filaments were welded together, presumably due to the flowing of the aluminium coating under pressure. This is illustrated in figure 5. From these experiments it was obvious that only a hard metal would be suitable so attention was concentrated on steel wires. Carbon filaments may also be suitable (although shattering could be a problem) but no experiments were carried out with them.

3.2 Static firing.

Several static firings were carried out in an enclosed firing site. Only the 0.2 mm diameter piano wire was represented but multifluted L.S.C.s with a twist from top to bottom of 0^o, 30^o and 60^o were used. Cutting in all cases was satisfactory with about 10% birdsnesting from the untwisted L.S.C.'s and about 3 to 5% from the twisted ones. The dipoles were badly deformed but this was due to them being projected against the concrete walls about 1.5 m distant. In contrast to this, the dipoles collected from the free field test were quite straight and the percentage of birdsnesting was about 3%. The birdsnesting in this case was caused by welding of the cut ends together as shown in figure 6 and the length of the dipoles indicates that this sample originated close to the centre of the spool. The L.S.C. used in the free field test was a twisted one (30^o) and the wire was 0.1 mm stainless steel. The dipoles were collected from a 30^o sector which was divided into four radial zones as shown in figure 7. The total weight collected in this sector was 45 g and an estimated 10 g remained embedded in the hessian. This is about 75% of that expected for even distribution over the full 360^o. The numbers of dipoles/m^2 in the four radial zones (derived from the weight collected and assuming a length of 25 mm) are shown in figure 7, and this shows that the bulk of the material fell within a 30 m diameter circle around the point of initiation. These figures also indicate that the cloud is torus shaped since the distribution of dipoles in the first three zones is 300, 600, and 400 per m^2 respectively.

3.3 Radar observed experiments

3.3.1 Helicopter suspended chaff generator

Problems with the suspension cable severely limited this series of experiments and only one firing was carried out. This involved a chaff generator with a 30^o twisted L.S.C. and a spool of stainless steel wire. It was suspended with its axis horizontal but the direction of the axis in relation to that of the radar was not known. The average signal strength increased from +13.7 db to +34 db on detonation and remained at this latter level for 90 s when recording ceased. This corresponds to a radar cross-section of the dipole cloud of 10 m^2 which is at considerable variance with the expected area of about 70 m^2. This aspect is discussed in Section 3.3.2.

3.3.2 Rocket launched chaff generation

All except one of the generators detonated satisfactorily. The exception was No. 3 which detonated at launch - probably due to the Bickford fuze being driven back onto the detonator by the acceleration loading. Its loss was relatively unimportant since No. 4 was a duplicate. The radar return from the chaff clouds in all cases was quite consistent from both radar sets and was equivalent to an echoing area of about 2.5 m^2. Theoretical estimates based on the actual dipole lengths (which vary from 20 mm to 30 mm) and on the distribution shown in figure 7, indicate that the echoing area should have been about 70 m^2 (ref.4). The reason for such a discrepancy is not known. Clumping and birdnesting of the dipoles has been suggested in explanation but this is at variance with all static test results and also at variance with reports of visual observations that the generators produced large and well developed chaff clouds.

The average time to bloom in those experiments was 12 ms. This corresponds to a distance, for a generator ejected from an aircraft travelling at Mach 1, of about 4 m. This assumes that detonation is

made to occur immediately on ejection which would not be desirable. Several metres would be a more acceptable distance before detonation occurred so a realistic distance to blooming could be up to 10 m.

4. CONCLUSIONS

These experiments with explosive chaff generators have demonstrated that very rapid blooming can be achieved. The radar echoing areas were considerably less than expected but no satisfactory explanation for this is available. If the theoretical performance could be achieved then the device might be of considerable value. No further investigation of this concept is planned in WSRL.

5. ACKNOWLEDGEMENTS

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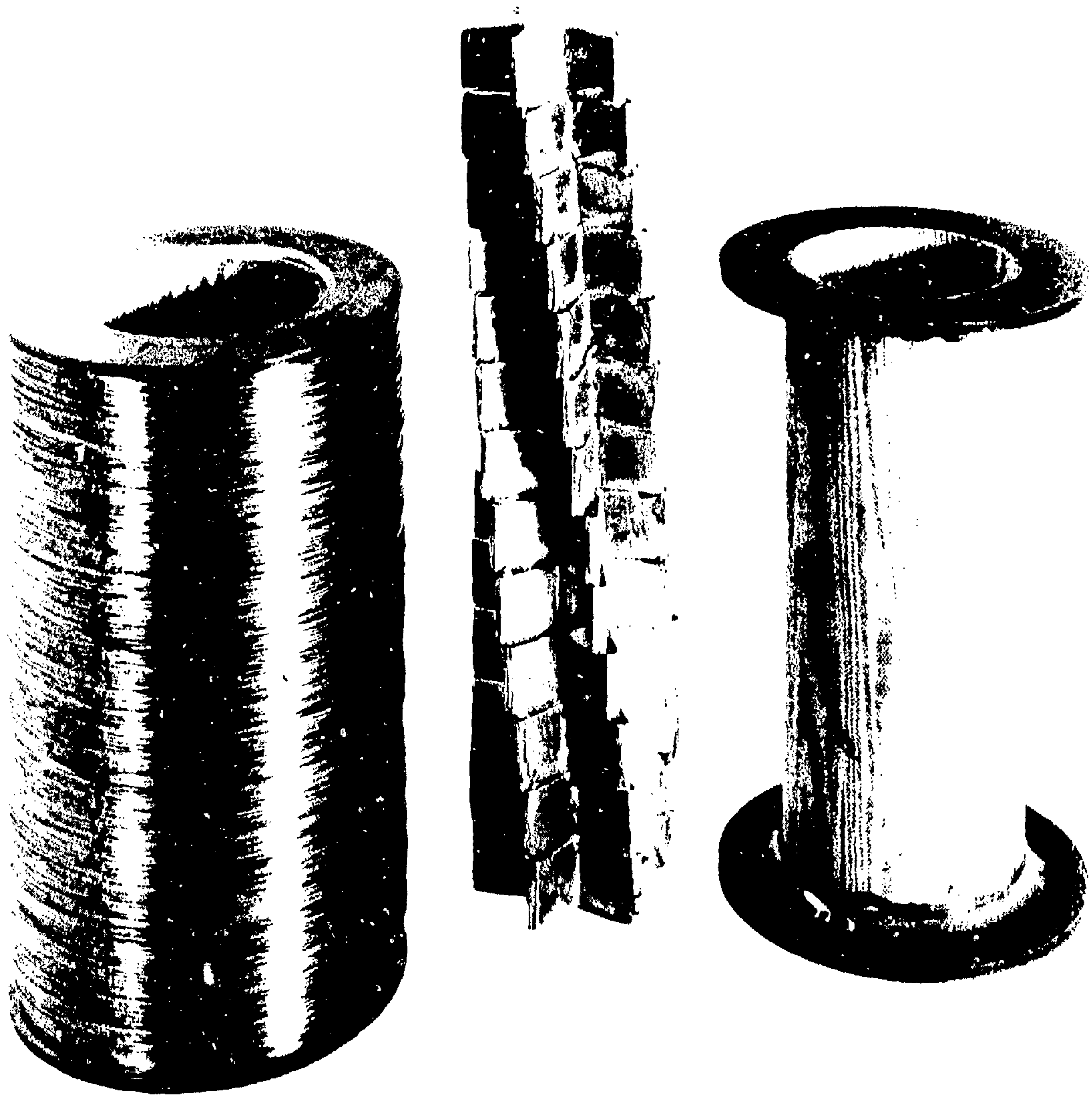

Figure 1. Basic elements of the chaff generator

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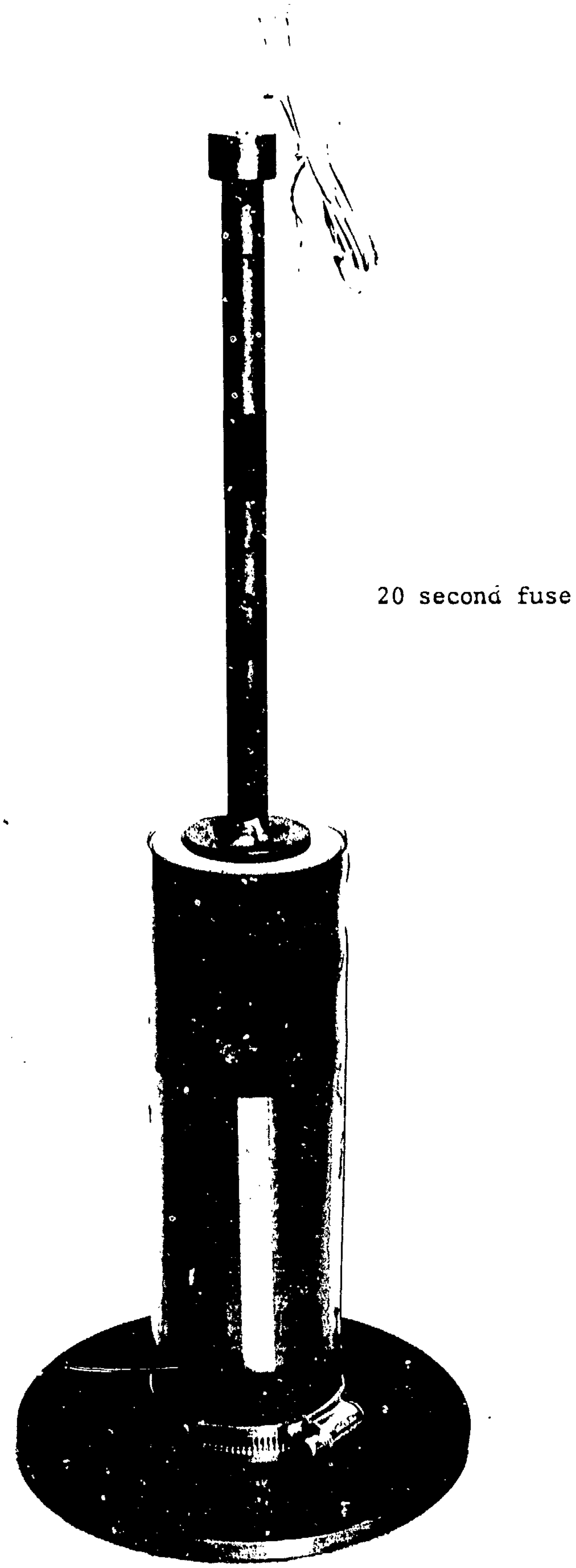

Figure 2. Chaff generator used in rocket launched experiments

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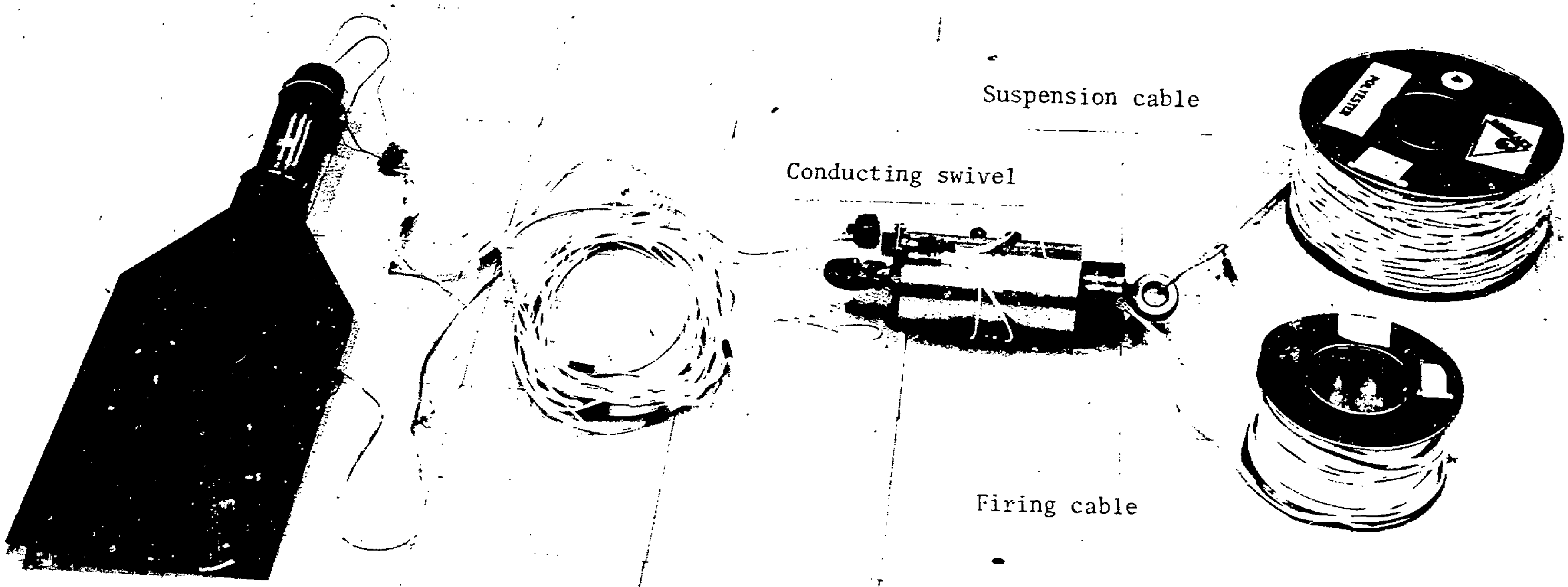

Figure 3. Chaff generator used suspended from helicopter

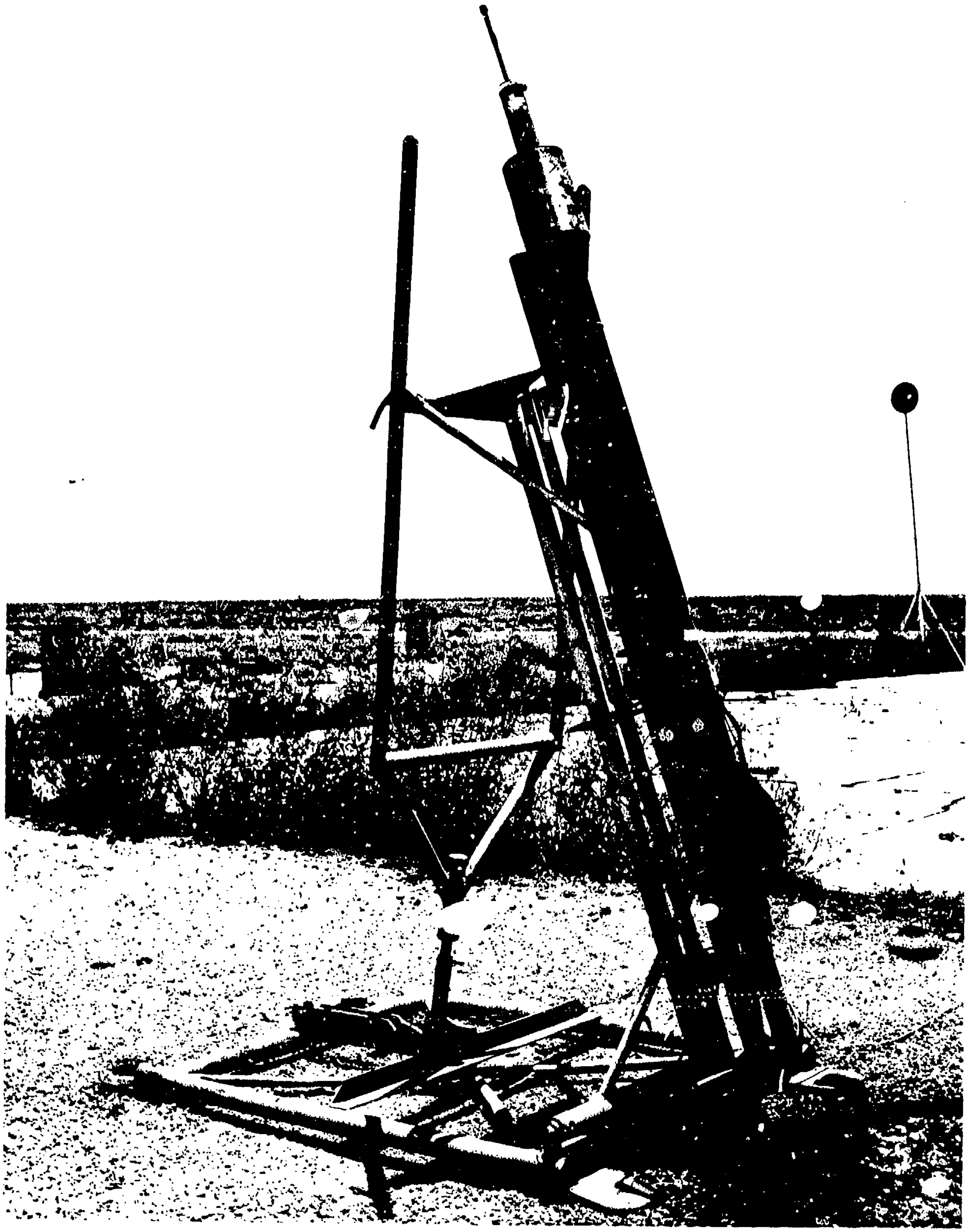

Figure 4. Chaff generator mounted on rocket

Figure 5. Cut ends of aluminium coated glass fibre

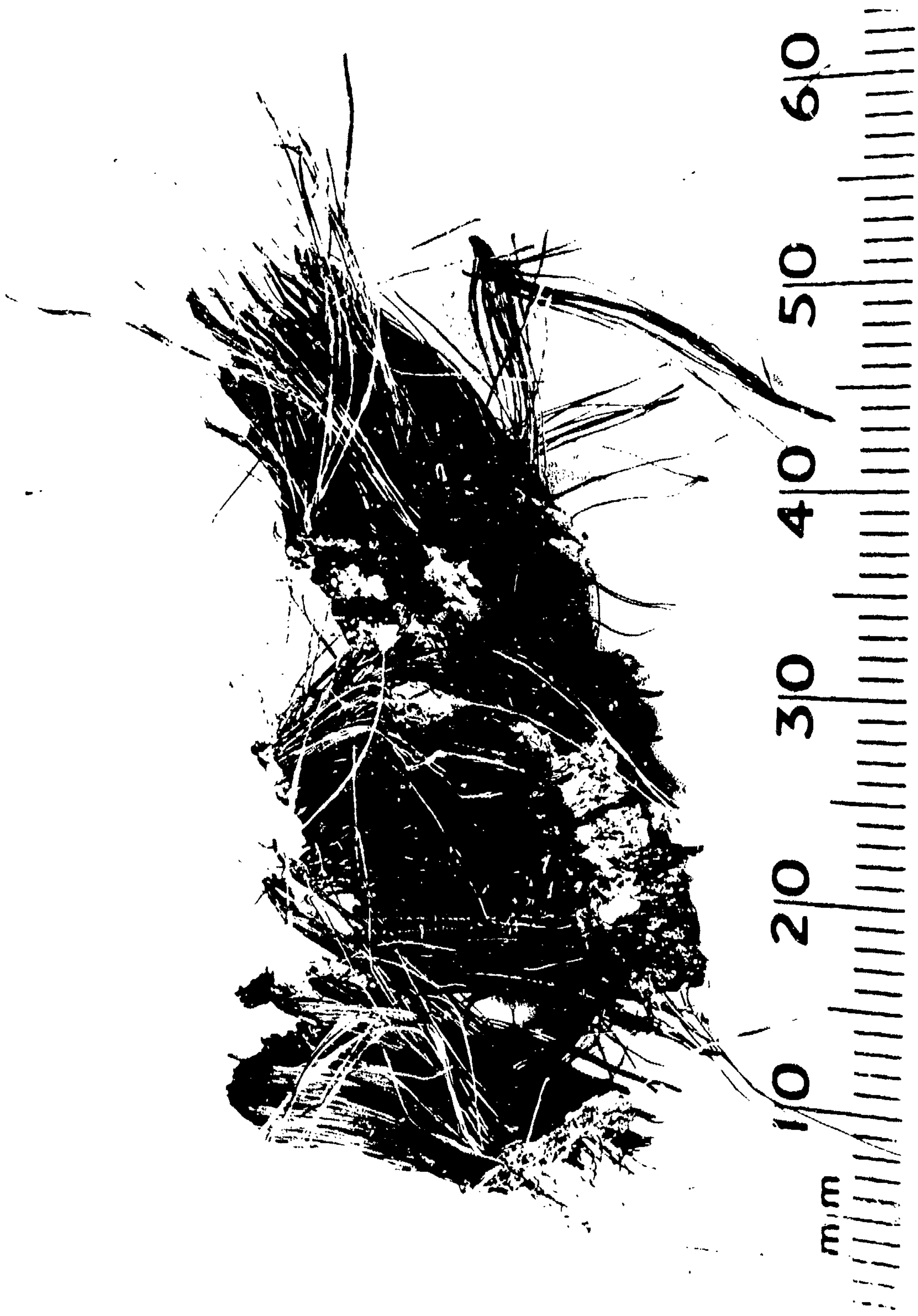

Figure 6. Example of birdnesting of stainless steel wire

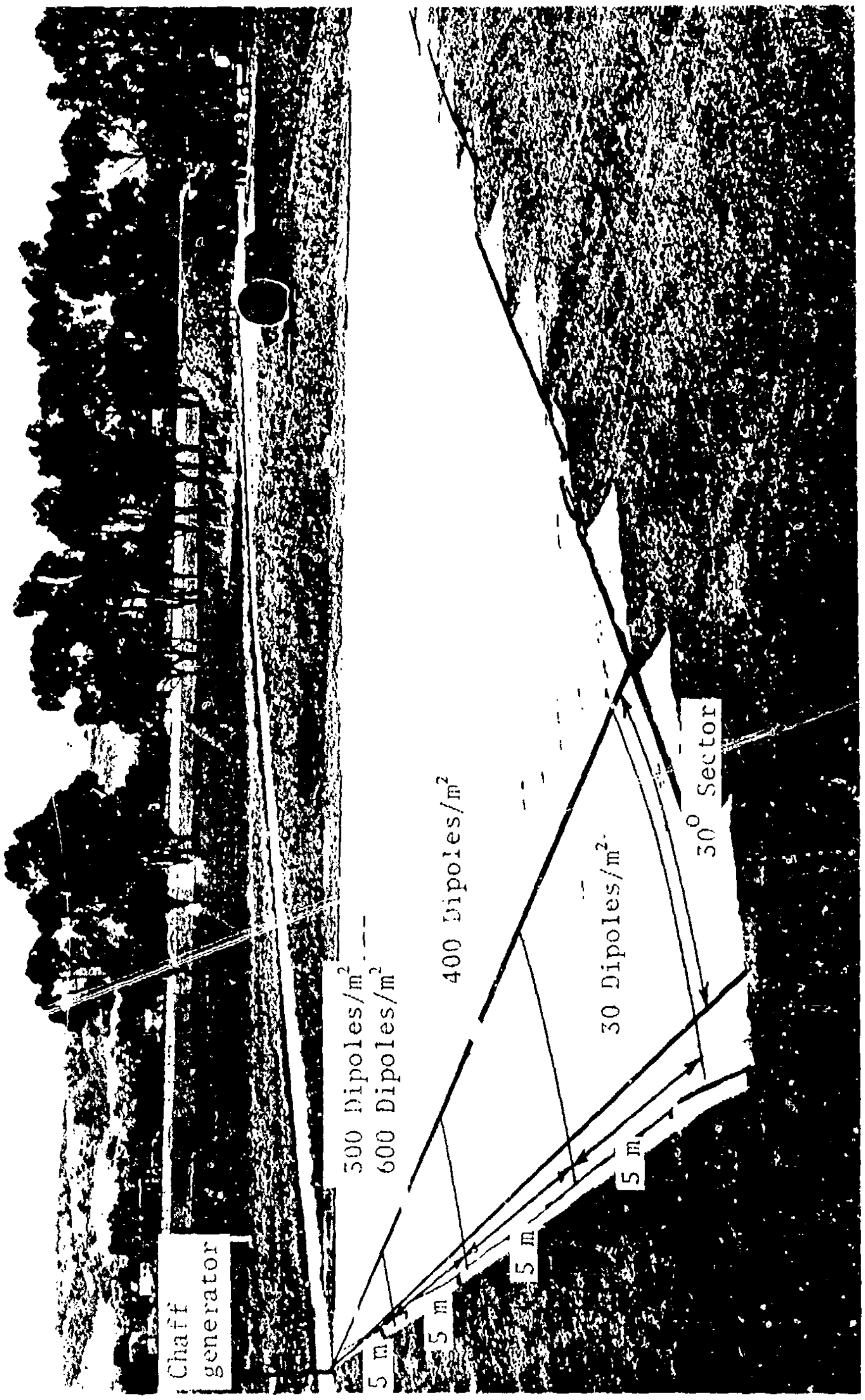

Figure 7. Distribution of dipoles from static firing

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